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Providing Antimicrobial Activity and Ultraviolet Protection on Wool Fabrics Using New Coloured Materials Based on Pyrimidine Derivatives

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Abstract

The textile industry is the second largest industry in Egypt and is important in the economy of the world. Medical textiles are the largest and fastest growing in the industry of textiles. Many compounds used in this field and new coloured compounds applied in the colouration of wool textile and as anti-microbial agents. The compounds with pyrimidine systems have different biological properties, pharmaceutical applications, medical and coloured materials used in different textile materials. The effect of thiopirido-pyrimidine derivatives on the colouring of wool and used as antimicrobials was examined. The colour fastness of the coloured wool fabrics and resistance to washing, Scanning Electron Microscopy (SEM) and radar chart diagram were also determined. The coloured wool has obtained as a good antimicrobial activity against (*Staphylococcus aureus)*, (*Escherichia coli), (Candida albicans*) and *Musor miehei* compared to uncolored wool. The impact of the new colour materials used as a finishing agent on both the shrinkage % and the recovery by moisture was investigated. The effects of the new coloured properties on wool fabrics and certain functional properties were identified and characterized. The products used as effective antimicrobial agents and will application in future works for textiles. Key Words: Wool fabric, Pyrimidine derivatives, Radar chart, Antimicrobial activity

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1. Introduction

The textile is good media for growth of microorganisms such as pathogenic bacteria, where the fabric is worn effect to the skin microbes cause cross infection by pathogens. In addition, the staining and loss of the performance properties of textile substrates are the results of microbial attack. In the recent years, several researches focused on finishing textiles with antimicrobial agents. Demand for multifunctional fabrics with UV protection, anti-microbial properties, good moisture management, resistance and other comfort properties is increasing for the fabric is used for the basic function of human body coverage [1]. The microbial growth of textile materials has been seen as a major cause of biodegradation and requires the development of antimicrobial activity for textiles, with an emphasis on developing durable and powerful antimicrobial finishing technologies and applications [2]. Improvement of the antibacterial activity and UPF protection on wool fabrics and polyamide fabrics with nano-silica treatment was reported [3]. Modification wool fabrics with anisotropic silver nanoparticles exhibited the modified wool brilliant colours due to the localized surface plasma on resonance properties of AgNPs. The treatment of wool fabrics indicated an antimicrobial activity against both Staphylococcus aureus and Escherichia coli bacteria [4].

Pyrimidines which contain heterocyclic compounds are an important class of compounds in medicinal chemistry and pharmaceutical

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applications. The importance of the pyrimidine class as antimicrobial agents along with clinical applications to facilitate the development of more potent pyrimidine compounds, as well as a more effective antimicrobial agents used in therapeutic applications warm water, then cold water and leave to air dry.

2.3. Dyeing

The solution of the dyeing bath was prepared by pasted the required amount of the new coloured materials using shade (2% (of weight of fabrics.) and then dissolving it by adding hot water. To adjust the pH of the dyeing bath solution to 4- 4.5, with use citric acid, then heated to 85$_o$C and added the wool fabrics for 1 hr., at liquor ratio 1:100. The dyed fabric was washed thoroughly with tap water and then use air-dried. [5].

The other advantageous property of these compounds is their utility as coloured materials and dyes. In addition, the classes of chemical compounds containing pyrimidines have been used as antibacterial activity of textiles [6]. The effect of the pyrimidine derivatives such as aminothioxopyrido pyrimidine derivatives as new coloured materials on various types of textiles was studied. The dyed wool fabrics with new colored materials are enhanced as well as dyed wool fabric with excellent ultraviolet protection [7]. The thiazolidine derivative was prepared and used as a novel colorant as well as antibacterial agent [8, 9]. Pyrimidine derivatives are important class applied in medicinal chemistry, pharmaceutical applications, biological activities and industrial of textiles [10-13]. The aim of the present work investigates the effect of new coloured materials, which are prepared as antibacterial finishing agent and its durability are determined. The color strength (k/s) of wool fabrics was determined in addition to moisture regain and surface morphology. This work will be applied in future work in textiles due to their good biological activity.

2. Materials and Methods

2.1. New coloured material and reagents

New coloured materials were prepared as shown in the article (Bassyouni et al 2020) [7] The new coloured materials are Oxo-4-thioxopyrido [2,3-d]pyrimidine-carbonitrile derivative and Thioxopyrido [2,3-d] pyrimidine derivative.

2.2. Fabrics

The wool fabrics used in this research was purchased from Misr for Spinning and Weaving Co., El Mehalla El Kobra, Egypt. The wool fabrics are washed for 30 min at 30 $_o$C in a 2% nonionic detergent, which based on weight of fabric, fabric: liquor ratio, 1:50. The washed fabrics are rinsed with

3. Measurements

3.1. Calorimetric measurements

The spectrophotometer was used to determine the colourimetric analysis of the dyed fabrics. (Ultra-Scan Pro, Hunter Lab, USA) at 10° C observed with D65 illuminate, d/2 which is viewing geometry and measuring surface area of 2 mm. All measurements were the appropriate wavelength (λmax). The value of the colour strength (K/S) has been evaluated by applying the specified method identified [15].

3.2. Fastness Properties

According to ISO standard methods fastness properties of the dyed samples were determined. The test ISO 105-C06 (2010) used to measure the colour fastness to washing; and ISO 105-E04:2013, to measure the colour fastness to perspiration (both acid and alkaline medium); and ISO 105-B02 (2014), colour fastness to light and rubbing (AATCC method) [14].

3.3. Moisture Regain %

Measurements of moisture regain of the coloured wool fabrics performed according to the standard ASTM method 2654–76. Moisture regain of the coloured wool fabrics calculated according to the following equation:

$$Moisture\ regain\ \% = \frac{W_1 - W_2}{W_1}\ x\ 100 \ldots\ldots\ldots (1)$$

W1 shows the weight of sample (gm) after saturation in the standard humidity atmosphere.

W_2 shows the constant weight (gm) of dry sample.

3.4. Electron Microscopy (SEM)

The surface morphology structure of undyed wool fabrics and the dyed wool fabrics was investigated by FE-SEM Quanta FEG 250. All samples were tested without pre-gold sputtering. ***3.5.***

Infrared Spectra (FTIR) The Infrared spectrum was tested on FT-IR Nicolet 5DX Spectrophotometer. The all samples (undyed and dyed wool fabrics) were examined as 1.5% KBr pellets.

3.6. UV-Protection

The UPF of undyed and dyed wool fabrics (size 3 cm× 3 cm) was determined in the Center Lab of the Industrial Textile Institute. The test carried out according to the Australian/New Zealand standard (AS/NZS 4366-1996) using UV-Shimadzu 3101 PC spectrophotometer at wavelength between 280 to 390 nm, which includes the UVB (280 to 320 nm) and the UVA (290 to 400 nm). UPF test was measured according to (ASTM-D6603).

4. Biological activity: Antimicrobial activity assay

Antimicrobial activity has been measured to determine the efficacy of the new colored material on uncoloured and coloured wool fabrics to reduce bacterial effect. The biological tests for both antibacterial and antifungal activities were carried out in the Microbial Chemistry Department, National Research Centre, by measuring the optical density (OD) at 600 nm. The method can be described as follows: The bacterial cultures maintained on nutrient agar slants were aseptically inoculated into 5 ml of sterile nutrient broth. The undyed and dyed wool fabrics were thoroughly shacked and then incubated at 37 0C for 24 h. This was designated as the working stock that was used for antibacterial studies. 5 ml of nutrient broth medium was taken in different test tubes and autoclaved. Each tube was inoculated with 100 lL of bacterial suspension and a disc of the tested specimen then incubated at 37 0C for 24hs. The growth of the selected bacteria was detected by optical density (OD) at 600 nm. The antimicrobial activity of the tested compounds was examined with gram positive bacteria, *Bacillus cereus, staphylococcus aureus ATCC 6538*, and gram-negative bacteria *Escherichia coli NRRN 3008, pseudomonas aeruginosa* ATCC 10145 and fungus Candida albicans EMCC105 [[16-24]. The obtained results were compared with the reference antibiotic Cephradine that was purchased from Egyptian markets

5. Results and Discussion

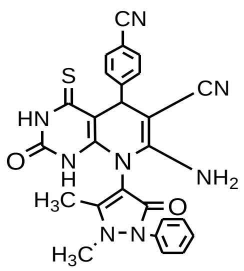
5.1. The new colored materials

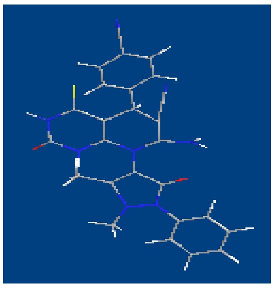
0The description of the prepared new coloured materials illustrated in (Table 1). In this work, the prepared compounds containing pyrimidine derivatives are proved interesting for their potentiality as new coloring materials, which used as dyes for dyeing wool fabrics **(Bassyouni et al 2020)**. The new coloured compounds containing several functional groups such as NH_2 group amino group, CH_3 group methyl group, NH group, NH_2 group , Sulpher group, C=S , CN group, and C=O group. We report here the synthesis of pyrimidine derivatives using a mixture of aryledine derivatives, 2-thioxo-dihydropyrimidine-4, 6 (1H,5H) dione and 4-aminoantipyrine and/ or rhodanine derivative as starting materials as multicomponent reaction system (*Bassyouni et al 2020*) [7]. The description of the new coloured materials P1 and P2 are shown in table 1.

Table 1: The new coloured materials P1 and P2

New coloured material compound	Specification of new coloured material
P1	**Oxo-4-thioxopyrido[2,3-d]pyrimidine-6-carbonitrile derivative**
P2	**Thioxathiazolidine pyrido[2,3-d]pyrimidine derivative**

Physical chemical properties of compound P1 and 3D structure property





Amino-(4-cyanophenyl)-hexahydro-(2, 3-dihydro-dimethyl-3-oxo-phenyl-1H-pyrazolyl)-oxo-thioxopyrido[2,3-d]pyrimidine-6-carbonitrile derivative

$C_{26}H_{20}N_8O_2S$: Mol. Wt.: 508.554, (28.1%), 510.139 (4.5%), 510.150 (3.8%), 509.140 (3.0%), 511.142 (1.3%), C, 61.41; H, 3.96; N, 22.03; O, 6.29; S, 6.31.

Log P: 1.16

MR: 140.71 [cm^3/mol]

Henry's Law constant: 2.43

CLogP: 1.00962

CMR: 14.39

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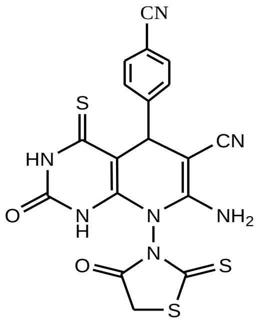
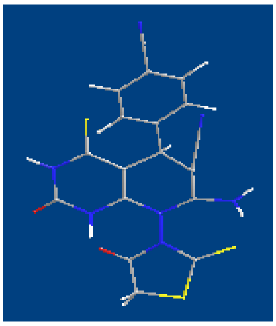
Physical chemical properties of compound P2 and 3D structure property





7-amino-5-(4-cyanophenyl)-1, 2, 3, 4, 5, 8-hexahydro-2-oxo-(4-oxo-2-thioxothiazolidinyl)-4-thioxopyrido[2,3-d]pyrimidine-6-carbonitrile

$C_{18}H_{11}N_7O_2S_3$, Mol. Wt.: 453.521 , m/e: 453.014 (100.0%), 454.017 (19.5%), 455.009 (13.6%), 456.013 (2.7%), 454.011 (2.6%), 454.013 (2.4%), 455.020 (1.8%)

C, 47.67; H, 2.44; N, 21.62; O, 7.06; S, 21.21

Henry's Law: 2.43
CLogP: 1.085
CMR: 12.334

5.2. Colour strength, Shrinkage % and Moisture regain %

The colour strength, shrinkage % and moisture regain % of undyed and dyed woolen fabrics with new coloured materials in Table 2. The colour of the wool from both new colored materials (P1 and P2) has been colou red orange with P1 and yellow with P2. The new P1 colour materials have significant color strength than P2. It was also found that the colouring led to a slight reduction in shrinkage of dyed wool fabrics with new coloured materials (P1 and P2) than uncoloured wool fabrics. This can be attributed to found ionic bond between the new coloured material and wool, this combination has led to a reduction in the percentage of shrinkage. The value of moisture regain % increased after dyeing wool fabrics with both new coloured materials (**P1** and **P2**) especially with dyeing by **P1**. The moisture value regain % growth increased after dyeing the wool fabric with both new coloured materials (P1 and P2), especially when coloured by P1. The shrinkage results of % of uncoloured and coloured wool fabrics with new coloured materials (P1 and P2) indicate that % shrinkage has decreased than uncoloured, which may result from the formation a bond between the new dye molecule and the wool (Table 2).

Table 2: Shrinkage % and Moisture regain % of dyed and undyed wool fabrics

Wool Fabric	K/S value	Shrinkage %	Moisture regain %	Picture of coloured wool fabrics
Undyed	**1.01**	**5.16**	**10.1**	
P1	**29.18**	**5.06**	**10.51**	
P2	**6.2**	**5.02**	**10.22**	

5.3. *Fastness properties*

The data of the fastness properties such as washing, perspiration, rubbing and light of coloured wool fabrics with the coloured materials **P1** and **P2** have shown in (Table 3). The alteration of the washing fastness of coloured fabrics shown some changed when using both **P1** than **P2**. However, the value of the anti-staining for both white wool and polyamide fabrics which used gave good value when dyeing with the new coloured materials **P1** and **P2**. These results clarify that the coloured materials have good fastness. The values of the perspiration fastness for the both coloured materials shown that good and excellent values (4 and 4-5) exist in alkaline and acid conditions overall. As well as the rubbing fastness, clarify very well and excellent for the new dyes (**P1** and **P2**) respectively, in dry as well as wet conditions. The light values are good for both the dyed materials. The light fastness incorporated highest values 6 for **P1** and 7, respectively (Table 3).

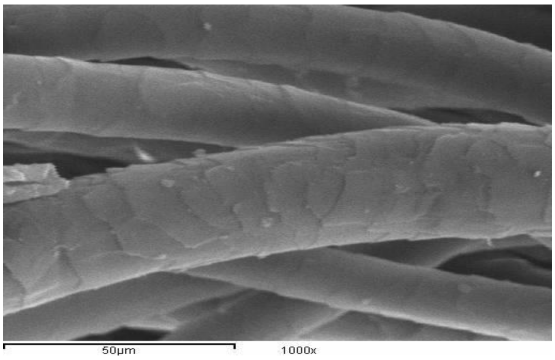
Table 3: Fastness properties of coloured wool fabrics

Sample Cod.	Washing fastness			Perspiration fastness				Rubbing fastness		Light fastness
	Alt	St_W	St_p	Acidic		Alkaline		Dry	Wet	
				Alt	St.	Alt	St.			
P1	3-4	4	4	4-5	4-5	4-5	4-5	4-5	4-5	6
P2	4	3-4	3-4	4-5	4-5	4	4	3-4	3-4	7

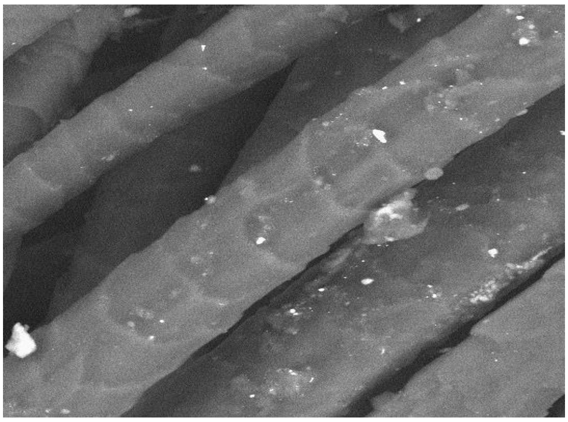
Alt.: Colour alteration, St_W: Staining of wool fabrics, St_P: Staining of polyamide fabrics

5.4. Surface morphology

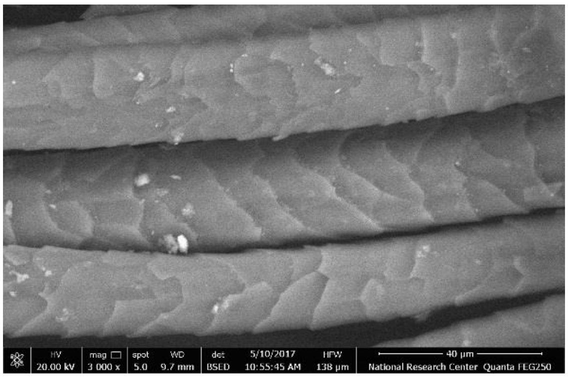
Changes of the of wool surface morphology fabric after dyed with new coloured materials (P1 and P2) were investigated using SEM represented in figure 1, (Uncoloured, P1 and P2). The Scanning Electron Microscopy analysis of surface morphology shows al little changes that occur on the surface of wool fabric due to dyeing with both materials (P1 and P2). The new coloured materials (P1 and P2) may be linked with wool fabric by ionic link as accepted with FTIR results.



Un-coloured



P1



P2

Figure 1: SEM of the un-coloured and coloured wool fabrics P1 and P2

5.5. Fourier Transform Infrared Spectroscopy

Figure 2 shows the Fourier Transform Infrared Spectroscopy (FTIR) of uncoloured wool fabrics and coloured wool fabrics with both **P1** and **P2**. The FTIR spectral analysis was performed at region from 4000 to 400 cm^{-1} performed. FTIR data of **P2** reveals the appearance of the broad peak for OH and NH groups from 3638.17 cm^{-1} to 3132.96 cm^{-1}. In the spectrum of the coloured wool fabrics with new coloured **P2** shows that absorption peak at 3441 cm^{-1} confirm the presence of (OH) corresponding to the broad intermolecular hydrogen bonded (OH) between amino groups of new coloured material and carboxyl groups .

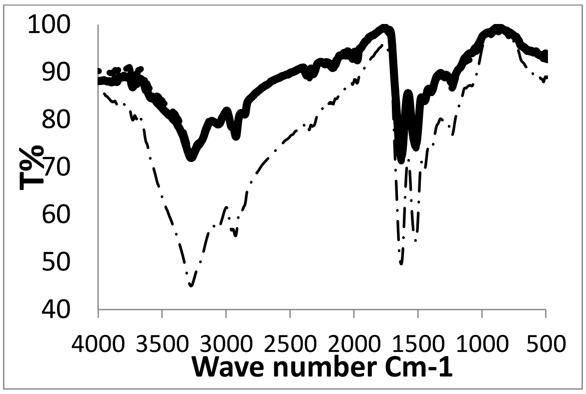


Figure 2: Fourier Transform Infrared Spectroscopy (FTIR) of uncoloured wool fabrics and coloured wool fabrics

5.6. Antimicrobial activity

The microbial growth of textile materials has been seen as a major cause of biodegradation and requires the development of antimicrobial activity for textiles, with an emphasis on developing durable and powerful antimicrobial finishing technologies and applications.

Table 4 shows the effect of new coloured material in antimicrobial activity of undyed and dyed wool fabrics with both **P1** and **P2.** The wool fabric were tested against both gram positive (*Staphylococcus aureus),* gram negative (*Escherichia coli*), Pathogen yeast (*Candida albicans*) in addition to two fungal strains and *Mucor miehei*. The obtained results revealed that sample **P1** has the ability to inhibit all the tested microbial groups with good results. excellent resistance for E. coli and excellent durability [106].

Table 4: Antimicrobial activity of wool dyed with P1 and P2 coloured materials

Microorganism	Gram Stain Reaction	Reduction in optical Density at 600 nm (%) Compound No	
		P1	**P2**
Staphylococcus aureus	**Positive**	**60**	**47**
Escherichia coli	**Negative**	**85**	**10**
Candida albicans	**Yeast**	**90**	**95**
		Clear zone (mm)	
Mucor miehei	**Fungi**	**50**	**10**

Table 5: Antimicrobial activity of wool dyed with P1 and P2 after washing

Microorganism	Gram Stain Reaction	Reduction in optical Density at 600 nm (%) Compound No	
		P1	**P2**
Staphylococcus aureus	**Positive**	**45**	**58**
Escherichia coli	**Negative**	**85**	**35**
Candida albicans	**Yeast**	**71**	**64**
Mucor miehei	**Fungi**	**30**	**46**

Table **5** revealed the results of antimicrobial activity dyed wool fabrics with both **P1** and **P2** after washing cycles. The dyed wool fabric were washed five washes and were tested again against both gram positive (*Staphylococcus aureus),* gram negative (*Escherichia coli*), Pathogen yeast (*Candida albicans*) as well as fungal strains and *Mucor miehei.* It found that the dyed fabrics with **P1** is very good activity against all the bacterial and fungal and well than the dyed fabrics with **P2.** These results indicated the **P1** is more stable and more effective as dye on the fabrics than the **P2** on fabrics.

5.7. Ultraviolet protection

Table 6 shows the UPF rating for wool patterns uncoloured and coloured with new coloured materials **P1** and **P2**. The new coloured materials led to a significant increase UV protection compared to an undyed one. The results indicate that the dyeing with **P2** coloured material has very excellent protection 50+ which the highest value compared with the coloured material **P1** has excellent protection 40+. The resistance of the dyed fabrics to ultraviolet radiation with that new coloured material **P2** acts as a photo protective substance and it improves dyed wool fabric absorbance (more than 98.0%).

5.8. Radar chart

The radar chart diagram for uncolored wool and colored woolen fabrics with P1 and P2 (new colored materials) as shown in (Fig. 3). It has been observed that the radar diagram area of coloured wool from P1 is the best, followed by coloured wool fabric with the radar graph area P2. This can be attributed to the effect of the chemical structure of new colored materials as good colouring agents.

Sample cod	UPF	UPF category
Untreated	30	Very good protection
dyed with P1	44	Excellent protection
dyed with P2	55	Very Excellent protection

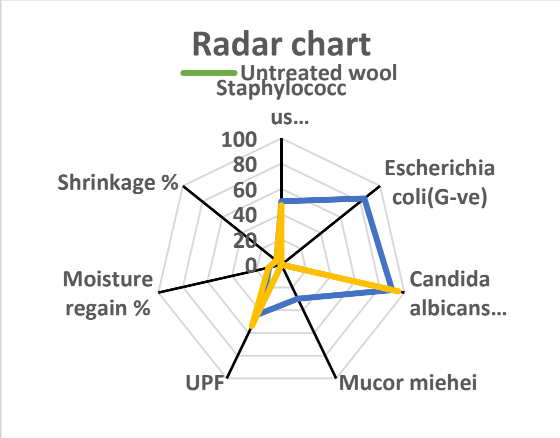


Fig. 3: Radar chart of **uncoloured wool fabrics and coloured wool fabrics**

Conclusion

The textile industry is increasingly examining strategies for applications in the textiles. For this reason we applied new materials dyed for wool was obtained with light fastness properties as new dyes. An excellent fastness property was found and can be applied in the future textile industry.

It has been found that:

1- A novel pyrimidine derivatives were synthesized by using Thioxathiazolidine pyrido[2,3-d]pyrimidine derivatives as starting new dye materials.
2- The results shows that the wool fabrics was dyed with high shade of orange colour and yellow colour as good new coloured materials (**P1** and **P2**), respectively.
3- The new coloured material **P1** has best colour strength value and best fastness properties than the new coloured material **P2**.
4- The results indicated that both new-coloured material **P1** and **P2** increased antimicrobial activity for wool fabrics the significant activity with follows *Escherichia coli*, Candida *albicans*, (*Staphylococcus aureus)*, and *Mucor miehei.*
5- SEM shows the new coloured material P1 and P2 mead adhesions on wool fabrics.
6- After the fifth washing cycle, dyed wool fabrics still have good antimicrobial activity and increases with dyeing of fabrics.
7- The application of the new coloured materials to providing them for antimicrobial activity, which applied in multifunctional textile with improved the properties is expected in the near future work and applications in textiles industry.
8- The colour fastness properties are ranged from very good to excellent in cases of fabric structures by new colour materials.

Declaration of conflicting interests

The authors declared that no conflicts of interest with respect to the research, authorship and/or publication of this article.

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References

1. Gao Y. and Cranston R.; “Recent Advances in Antimicrobial Treatments of Textiles” Textile, Research Journal, 2008, 78(1): 60–72.
2. Sharma P.; Kaur H.; Sharma M.; Sahore V.; “A review on applicability of naturally available adsorbents for the removal of hazardous dyes from aqueous waste” Environ. Monit. Assess, 2011, 183:151–195.
3. Akşit A; Nurhan O Çamlıbel; Esra Topel Z ; Bengi Kutlu; Development of antibacterial fabrics by treatment with Ag-doped TiO2 nanoparticles, Journal of the Textile Institute, 2017, 108 (12).
4. Maleknia L.; Aala A. A.; and Yousefi K.; “Antibacterial properties of nanosized silver colloidal solution on wool fabric,” Asian Journal of Chemistry, 2010, 22, 8, p. 5925–5929.
5. Ramesh B; and Sumana T., Synthesis and antimicrobial screening of new pyrimidine derivatives” International Journal of Pharmaceutical Science, 2009, 1, 2, 320-322.
6. Chung K.. T.; Azo dyes and human health: A review. J. Environ. Sci. Health C Environ. Carcinog, Ecotoxicol. Rev., 2016, 34, 233–261.
7. Bassyouni F., Seddik K. M.; Abdel-Megied Z. M.; and El Gabry L. K. “Characterization of New Coloured Materials on Different Fabrics and Application on Wool Fabrics to Comfort and Ultraviolet Protective Garment ” Egypt. J. Chem., 2020, 63, 7, 2751-2761.
8. Abou El-Kheir A.; Ezzat M.; Bassiouny F. A; El-Gabry L. K.; “Development of some functional properties on viscose fabrics using nano kaolin” Cellulose, 2018, 25:4805–4818.

9. Abd Alhameed R. ; Almarhoon Z.; Sarah I.

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Bukhari; El-Faham A.; Beatriz G. de la Torre; Fernando Albericio; Synthesis and Antimicrobial Activity of a New Series of Thiazolidine-2,4-diones Carboxamide and Amino Acid Derivatives, *Molecules* 2020, *25*(1),105; https://doi.org/10.3390/molecules, 25010105

10. Tian, Y.; Du, D.; Rai, D.; Wang, L.; Liu, H.; Zhan, P.; Clercq, C.; Pannecouque, E.D.; Liu,X. "Fused heterocyclic compounds bearing bridgehead nitrogen as potent HIV-1 NNRTIs. Part 1: Design, synthesis and biological evaluation of novel 5, 7-disubstituted pyrazolo[1,5- a]pyrimidine derivatives" Bioorg. Med. Chem., 2014, 22, 2052–2059.

11. Tawfik H. A.; Bassyouni F. A.; Gamal El-Deen A. M.; Abo- Zied M. A. and El-Hamouly W. S., Tumor "Anti–initiating Activity of Some Novel 3,4-Dihydropyrimidinones" Pharmacological Reports, ٢٠١٠, 61, 1153-1162.

12. Amani M. R. Alsaedi; Thoraya. A. Farghaly; Mohamed R. Shaaba; "Synthesis and Antimicrobial Evaluation of Novel Pyrazolopyrimidines Incorporated with Mono- and Diphenylsulfonyl Groups" Molecules, 2019, 24, doi:10.3390/molecules, 24214009

13. Cherukupalli, S.; Karpoormath, R.; Chandrasekaran, B.; Hampannavar, G.A.; Thapliyal, N.; "Palakollu, V.N.An insight on synthetic and medicinal aspects of pyrazolo[1,5-a] pyrimidine scaffold" Eur. J. Med. Chem. 2017, 126, 298–352.

14. AATCC, Technical Manual, Method 15 (1989), 68, (1993). 30–32

15. Sadi Md S.; Hossain Md J, Measurement of the relationship between shade (%), reflectance (%) and color strength (K/S), Dyeing, Finishing & Printing , 2017, 4:27:19

16. Montazer M.; Behzadnia A.; Pakdel E.; Rahimi M. K.; and Moghadam M. B., "Photo induced silver on nano titanium dioxide as an enhanced antimicrobial agent for wool," Journal of Photochemistry and Photobiology B, 2011, 103, 3, pp. 207– 214.

17. Bassyouni F. A; Abu-Baker S. M.; Mahmoud K.; Moharam M.; El-Nakkady S. S. and Abdel Rehime M., Synthesis and biological evaluation of some new triazolo[1,5 a] quinoline derivatives as anticancer and antimicrobial, RSC Advances, 2014, 24131-24141.

18. Gao, Y.; Cranston, R. Recent advances in antimicrobial treatments of textiles. Text. Res. J. 2008, 78, 60–72.

19. Simoncic, B.; Tomsic, B. Structures of novel antimicrobial agents for textiles. A review. Text. Res. J. 2010, 80, 1721–1737.

20. Seth, M.; Jana, S. Nanomaterial based super hydrophobic and antimicrobial coatings, Nano World J. 2020, 6, 26–28.

21. Bassyouni F **;** Tarek M. ; Salama A.; Ibrahim B.; Salah El Dine S.; Yassin N.; Hassanein A. ; Moharam M. and Abdel-Rehim M, Promising Antidiabetic and Antimicrobial Agents Based on Fused Pyrimidine Derivatives: Molecular Modeling and Biological Evaluation with Histopathological Effect, *Molecules* 2021, 26, 2370. https://doi.org/10.3390/molecules26082370

22. Bassyouni F.; El Hefnawi M.; El Rashed A.; Abdel Reheem M.; Molecular Modeling and Biological Activities of New Potent Antimicrobial, Anti-Inflammatory and Anti-Nociceptive of 5-Nitro Indoline-2-One Derivatives, Drug designing, 2017 6.2, 148,

23. Shakdofa M. M. E.; Mousa H. A; labib A. A. ; Abd El-All A. S. ; Bassyouni F. A.; *In vitro* Antimicrobial Activity Evaluation of Newly Synthesized Furochromone Schiff Base Complexes, Egypt. J. Chem., 2018, 61, No.2